Body Diffusion-Weighted MR Imaging Using High *b*-Value for Malignant Tumor Screening: Usefulness and Necessity of Referring to T2-Weighted Images and Creating Fusion Images[1]

Yoshito Tsushima, MD, Akie Takano, MD, Ayako Taketomi-Takahashi, MD, Keigo Endo, MD

Rationale and Objectives. To evaluate the potential usefulness of high *b*-value body diffusion-weighted images (DWIs) as a screening tool in the depiction of abdominal malignant tumors.

Materials and Methods. We selected 110 abdominal magnetic resonance examinations (1.5 T; 60 men; age range, 25–90 years) with and without malignant tumors ($n = 37$ and $n = 73$, respectively). Axial DWIs were obtained by single-shot spin-echo (SE) type echo planar imaging (EPI) sequence with inversion pulse (repetition time, 6,800 msec; echo time, 100 msec; T1, 150 msec; *b* value, 1,000 sec/mm^2) without breath-holding. Two radiologists independently interpreted the DWIs, T2-weighted images (T2-WI), all three types of images including DWIs, T2-WIs, and fusion images at the same time (DWIs + T2-WIs + fusion) with 7–14 days' interval, and the diagnostic confidence for each patient was scored.

Results. The area under the curve (AUC) of the composite receiver operating characteristic (ROC) curve of DWIs + T2-WIs + fusion (0.904) was significantly higher than those of DWIs (0.720; $P < .001$) and T2-WIs (0.822; $P < .05$). Both sensitivity and specificity were higher in DWIs + T2-WIs + fusion (89.5% and 81.9%, respectively) compared with those of DWIs (72.4% and 59.0%; $P < .01$ and $P < .001$, respectively).

Conclusions. Abdominal high *b*-value DWIs have a high sensitivity and specificity for malignant tumors when T2-WIs are referred and image fusion technique is employed, suggesting that it may potentially be a new screening tool.

Key Words. MRI; diffusion-weighted imaging; abdomen; malignant tumor; screening.

Recent advances in magnetic resonance (MR) technology allow us to obtain diffusion-weighted images (DWIs) with high *b*-factor not only in the brain but in the body, and the image quality of body DWIs has improved even under a free breathing using a short TI inversion recovery echo planar imaging sequence that allows potent fat suppression (1).

There have been several reports that showed the high ability of body DWIs to detect various malignant tumors (2–6). For instance, Ichikawa et al (2) reported that the high *b*-value DWIs allow detection of colorectal adenocarcinoma with a high sensitivity and specificity, and Nasu et al (3) reported that combined reading of DWIs, and T1- and T2-weighted images had the higher accuracy in the detection of hepatic metastases than did reading of superparamagnetic iron oxide particles (SPIO)-enhanced MR images. These reports let us suggest the potential capability of body DWIs as a screening tool for malignant tumors.

It is clearly a shortcoming of DWIs that precise anatomic localization of the abnormal signal intensity is occasionally difficult because most normal anatomic struc-

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[1] From the Department of Diagnostic Radiology and Nuclear Medicine, Gunma University Hospital, 3-39-22 Showa-machi, Maebashi, Gunma 371-8511, Japan (Y.T., A.T., A.T.-T., K.E.). Received January 15, 2007; accepted February 7, 2007. **Address correspondence to:** Y.T. e-mail: yoshito@xa2.so-net.ne.jp

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tures show little signal. This localization can be archived by means of image fusion between DWIs and, for instance, T2-weighted images (7). The signal intensity characteristics on T2-weighted images can also contribute to information in differentiating between malignant and benign tumors, which may show abnormal signal on DWIs.

The aims of this study were to evaluate the potential usefulness of high b-value body DWIs as screening tool in the depiction of malignant tumors in the abdomen, and to evaluate if there is additional value in referring T2-weighted images and creating fusion images between them.

MATERIALS AND METHODS

Patients

Between September 2005 and May 2006, approximately 300 body MR examinations were performed in our referral hospital (Motojima General Hospital, Ohta, Japan). All body MR examinations have included axial DWIs by echo planar imaging (EPI) with fat suppression technique in addition to conventional axial T1-weighted gradient echo (GE) and T2-weighted first spin echo (SE) images (T2-WIs). If necessary, enhanced T1-weighted GE images and other special imaging techniques such as MR cholangiopancreatography and MR angiography were performed.

From these MR examinations, we selected 110 MR examinations in 110 patients (60 men and 50 women; mean age ± standard deviation [SD], 59.9 ± 14.2; age range, 25–90 years) according to the following criteria: 1) enhanced computed tomography (CT) examination at the same anatomic location was also performed within 2 weeks and 2) the primary malignant tumor was pathologically verified if present. When a patient had no clinical symptoms or other clinical signs of malignancy, and there was no imaging evidence of malignant tumor on both MRI (at least T1-weighted axial GE and T2-weighted axial SE images were reviewed and DWIs were not referenced) and contrast-enhanced CT, the patient was considered to have no malignant tumor; 3) the patients showed no evidence of acute abdomen or any clinical suspicion of active inflammatory diseases.

In 82 patients, upper abdominal MRI were performed: 22 patients had malignant tumors in the obtained axial images (5 renal cell carcinomas, 4 advanced gastric carcinomas, 4 metastatic liver tumors, 3 pancreatic carcinomas, 2 hepatocellular carcinomas, 2 cholangiocarcinomas, 1 bone lesion of lymphoma, 1 transverse colon carcinoma), and 60 patients did not have malignant tumors. In 28 patients, pelvic MR imaging was performed: 15 patients had malignant tumors in the obtained axial images (5 rectal carcinomas, 3 ovarian carcinomas, 2 prostate carcinomas, 2 metastatic bone tumors, 1 peritoneal dissemination, 1 recurrent colon carcinoma, and 1 ascending colon carcinoma), and 13 patients had no malignant tumors. Thus, of all 110 patients, 37 patients had malignant tumors in the obtained MR images and 73 patients had no malignant tumors.

Institutional review board approval was obtained for this retrospective data analysis in Motojima General Hospital, and the board decided it was not necessary to obtain informed consent from each patient.

MR Imaging

All MR examinations were performed on a 1.5-T superconducting MR unit with a phase-array coil (EXCELART, Toshiba Medical Systems Co, Tochigi, Japan). First, axial T1-weighted GE images with breath holding (repetition time [TR], 129 msec; echo time [TE], 4 msec; flip angle, 70°; field of view [FOV], 28 × 35 cm; matrix, 168 × 336; slice thickness, 8 mm; acquisition time, 12 seconds) and T2-WIs without breath holding (TR, 2800 msec; TE, 80 msec; FOV, 28 × 35 cm; matrix, 192 × 384; slice thickness, 8 mm; acquisition time, 2 minutes 32 seconds) were obtained.

Then, at the same anatomic location, axial DWIs were obtained by single-shot SE type EPI sequence with inversion pulse (TR, 6800 msec; TE, 100 msec; TI, 150 msec; *b* value, 0 and 1000 sec/mm^2 number of acquisition, 6; FOV, 28 × 35 cm; matrix, 128 × 128; slice thickness, 8 mm; acquisition time, approximately 4 minutes) without breath-holding. The slice position and number of slice (15–19) were totally matched on T2-WIs and DWIs.

CT Imaging

Unenhanced and enhanced CT examinations were performed with single-detector helical CT unit (HiSpeed Advantage, GE Yokogawa Medical Systems Ltd, Tokyo, Japan). CT images were reconstructed with a standard reconstruction algorithm and a 512 × 512 matrix, 40–50 cm field of view, and 7-mm slice thickness.

Image Fusion Between DWIs and T2-WIs

All MR images were exported by DICOM protocol, and transferred to a Macintosh computer (MacOS X, version 10.4). The fusion images between DWIs and T2-WIs